植物研究雑誌
J. Jpn. Bot.
74: 34–41 (1999)

The Morphology of *Sargassum spathulophyllum*, sp. nov. (Fucales, Phaeophyceae) from Japan

Hiroshige MURAKAMI[a], Shogo ARAI[b] and Jiro TANAKA[c]

[a]Rinkai Seibutu Kenkyusho, Kinsi, Sumida-ku, Tokyo, 130-0013 JAPAN;
[b]Kaiso Kenkyusho, Shingu-machi, Kasuya-gun, Fukuoka, 811-0114 JAPAN;
[c]Tokyo University of Fisheries, Konan, Minato-ku, Tokyo, 108-8477 JAPAN

(Received May 7, 1998)

Sargassum spathulophyllum J.Tanaka, H.Murakami & S.Arai sp. nov. (Fucales, Phaeophyta) is described based on the materials from Shimoda, Izu Peninsula, Shizuoka Prefecture, central Japan. The new species has the following characteristics: 1) lower leaves simple, spatulate, entire and retroflexed at the base, 2) middle leaves vertical, 3) main branches ancipitous and smooth, 4) creeping stems with secondary attaching discs, 5) receptacles simple, smooth, non-terete and in a dense racemose cluster. The species is placed in the section Repentia of the subgenus Bactrophycus in the genus *Sargassum*. Morphological differences between the new species and some of the related species such as *S. okamurae*, *S. nigrifolium*, *S. yezoense*, and *S. yamadae* belonging to the section Repentia and *S. segii* of the section Halochloa in Bactrophycus are discussed.

Key words: *Sargassum spathulophyllum* sp. nov., Fucales, Phaeophyceae, taxonomy, morphology

Introduction

The brown algal genus *Sargassum* includes more than 400 described species (Yoshida 1983). They are specialized macroalgae morphologically with holdfast, stems, main branches, leaves, vesicles and receptacles (Yoshida 1983). These seaweeds are widely distributed from subtropical to temperate regions of the northern and southern hemispheres, often making dense marine forests on rocky shores (Yoshida 1989, Phillips 1995). Agardh (1889) divided the genus *Sargassum* into five subgenera; Bactrophycus, Arthrophycus, Phyllotrichia, Schizophycus and Sargassum. His system has been followed by most phycologists (Yendo 1907, Setchell 1931, Okamura 1956, Yoshida 1983, Tseng et al. 1985, Womersley 1987, Abbott 1995). Fifty eight species of *Sargassum* are listed from Japanese waters (Yoshida et al. 1995). Among them 30 species are the members of the subgenus Bactrophycus which occurs mainly in eastern Asia (Tseng et al. 1985), and it is especially diverse around Japan (Yoshida 1994). The members of Bactrophycus have several types of stems and receptacles. Yoshida (1983) described four sections, Spongocarpus Teretia, Halochloa and Repentia in this subgenus from Japan. A new species of the subgenus Bactrophycus was found in the central Pacific coast of Japan, and is described in this paper. The rank of the section to which it belongs is discussed.

Materials and Methods

Collections and observations were made at

Nabeta Bay (138°56'E, 34°40'N), Shimoda City, Shizuoka Prefecture, Pacific coast of central Japan, in every month from 1995 to 1996. Herbarium specimens were made for reservations, and deposited in the Museum of Tokyo University of Fisheries (MTUF-AL), the Herbarium of National Science Museum (TNS-AL) and Hokkaido University (SAP). The morphological terms used in the present paper are those used by Yoshida (1983).

Sargassum spathulophyllum J.Tanaka, H.Murakami & S.Arai, sp. nov. (Figs. 1–2)

Sargassum spathulophyllum J.Tanaka & H.Murakami in Yoshida, Marine Algae of Japan 407 (1998), nom. nud.

Japanese name: Hera-narasamo.

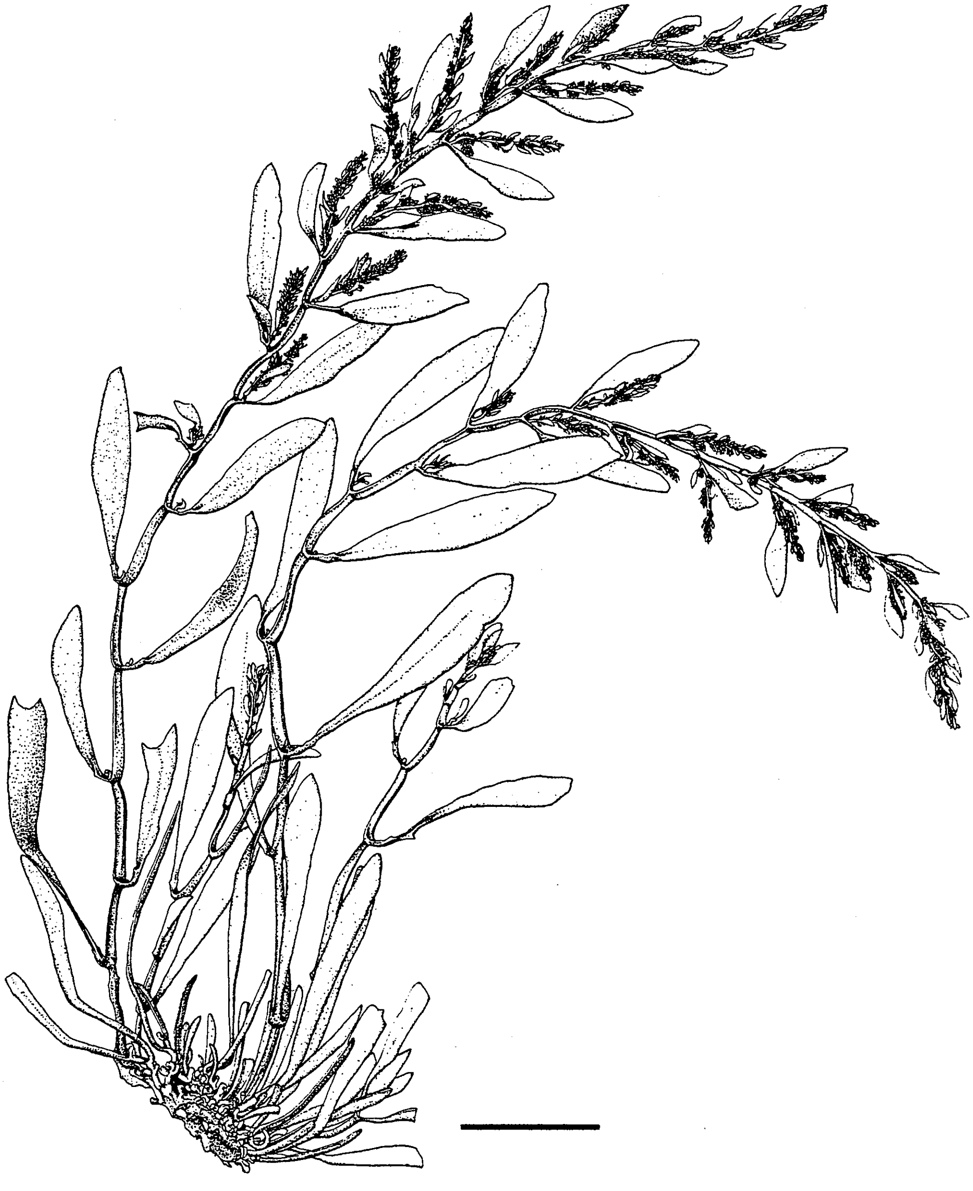

Fig. 1. *Sargassum spathulophyllum* J.Tanaka, H.Murakami & S.Arai, sp. nov. Whole thallus. Scale bar: 5 cm.

Description

Thallus usque ad 80 cm altus. Hapteron conicum, aliquot lobis. Caulis teres, ramosus, decumbens vel procumbens, 1.5–2 mm in diametro, discis affixis. Rami principales ancipitii vel compressa, usque ad 7 mm lata, ad marginem integeris. Phyllotaxis 1/2. Folia simplicia, spathulata ad oblanceolata, laeves, integra, apicibus obtusis, basibus cuneatis, retroflexa, horizontales vel verticales disposita. Rami laterales axiales. Cryptostomata absentia. Vesiculae raro, 20 mm longae, 5 mm in diametro, oblongae. Planta dioica. Receptacula simplicia vel raro ramosa, laeves, compressa vel subteres. Receptacula femina 1–6 mm longa, 0.5–1 mm lata. Receptacula masculina 4–10 mm longa, 1–1.5 mm lata.

Thallus up to 80 cm high. Holdfasts conical with lobes. Stems terete, branched, decumbent or procumbent, 1.5–2 mm in diameter, with attaching discs. Main branches ancipitous or compressed, 7 mm broad, with entire margins. Phyllotaxis 1/2. Leaves simple, spatulate to oblanceolate, smooth, entire, apices obtuse, bases cuneate, retroflexed, horizontal or vertical. Lateral branches axillary. Cryptostomata absent. Vesicles rare, 20 mm long, 5 mm in diameter, oblong. Thalli dioecious. Receptacles simple or occasionally divergent, smooth, compressed or subterete. Female receptacles 1–6 mm long, 0.5–1 mm wide. Male receptacles 4–10 mm long, 1–1.5 mm wide.

Holotypus: Nabeta Bay, Shimoda City, Shizuoka Prefecture, 23 July 1996, coll. H. Murakami (TNS-AL-45095).

Other specimens examined: Nabeta Bay, Shimoda City, Shizuoka Prefecture, coll. H.Murakami, 1995-5-9 (MTUF-AL-6510); 1995-6-9 (TNS-AL-45096); 1995-8-5 (MTUF-AL-6512; female plant); 1995-8-5 (MTUF-AL-6513; male plant); 1995-10-19 (MTUF-AL-6514); 1995-11-17 (MTUF-AL-6516); 1996-1-12 (MTUF-AL-6517); 1996-2-16 (MTUF-AL-6518); 1996-5-8 (MTUF-AL-6519); Nansei-cho, Mie Prefecture, coll. S. Arai, 1990-10-18 (SAP-061234); 1990-10-18 (SAP-061235).

Morphology

Thallus medium to dark brown, almost black in drying, rarely fluorescent in water, bushy, up to 80 cm high. Thallus composed of holdfast, stems and main branches (Fig. 1). Holdfast epilithic, conical, 10 mm across, with lobes from stems (Fig. 2-1). Stems terete, 1–2 cm long, 1.5–2 mm in diameter, branched, decumbent or procumbent, bearing apically or dorsally main branches, ventrally with small attaching discs, fused with each other or with a holdfast, forming a irregular basal part up to 10 cm across. Main branches ancipitous or compressed, up to 7 mm broad, with smooth, thinner margins, sometimes with longitudinal coastal elevations, terete to compressed at the base. Phyllotaxis 1/2 at the lower part. Leaves simple, entire, smooth, midribs evanescent. Basal leaves up to 15 cm long, 1.5 cm broad, linear with truncate apices and thick bases when young, spatulate to oblanceolate, occasionally hook-shaped (Fig. 2-2), thick, coriaceous, horizontal, ascending, apices often obtuse or sometimes apiculate, occasionally truncate, bases cuneate, petioles flat, entire, strongly retroflexed. Middle to upper leaves up to 10 cm long, 1.5 cm broad, oblanceolate or hemiphyllous, often lanceolate, conspicuously vertically disposed, apices obtuse or apiculate to acute, bases cuneate, tortuous, petioles flat, margin entire. Lateral branches axillary, 2–15 cm long or occasionally 30 cm or more, 1–2 mm broad, compressed or subterete, with round edges. Phyllotaxis 1/2 or 1/3. Cryptostomata absent. Vesicles usually absent, occasionally a few when older, 5–20 mm long, up to 5 mm in diameter, usually lanceolate with ellipsoidal to obovoid slightly bladdery centers, occasionally ellipsoidal, with ovate coronal leaves descending as wings, petiolate, usually singly on upper branchlets or rarely axillary (Fig. 2-3).

Thalli dioecious. Maturation in summer. Receptacles unisexual, aggregated in a dense racemose cluster on upper branchlets, usually

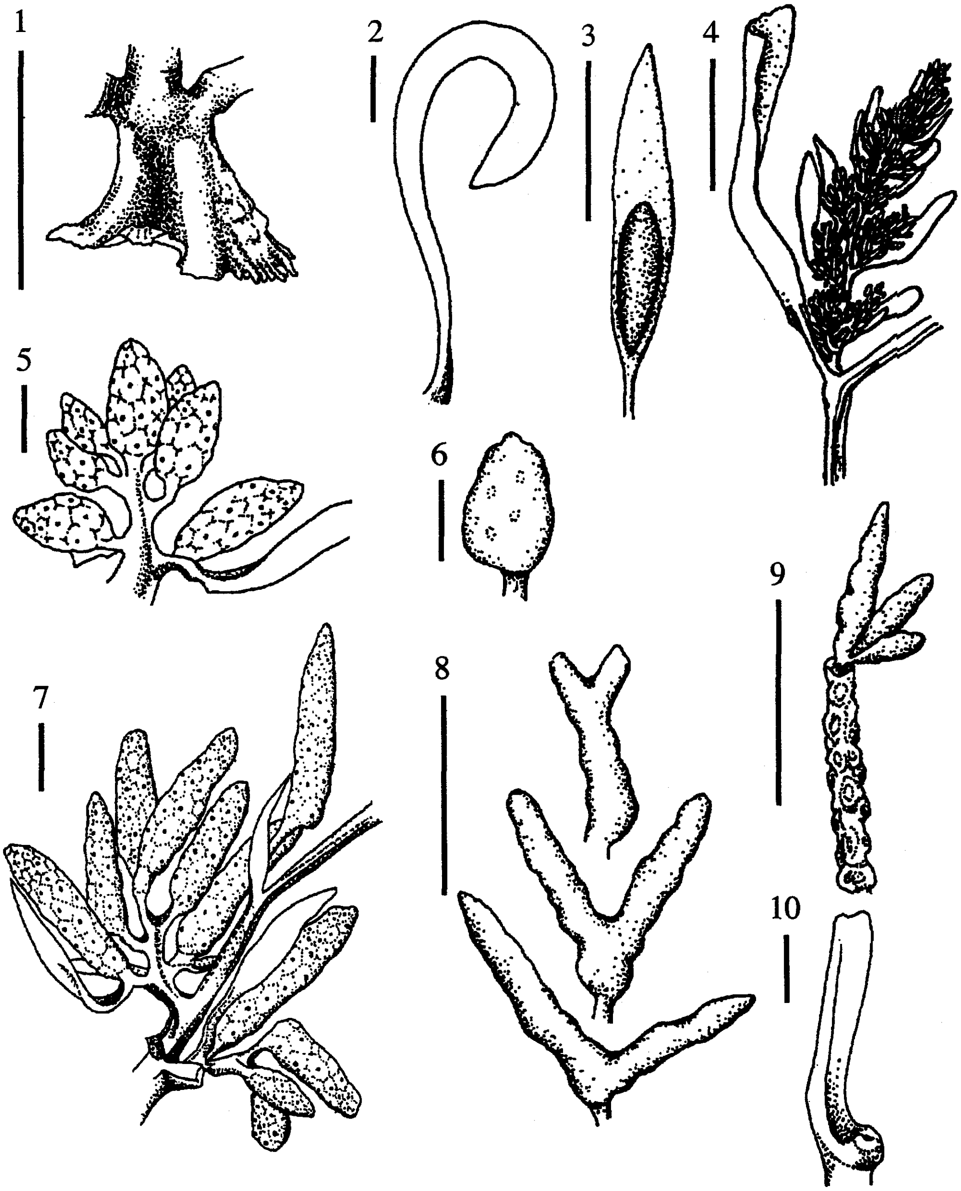

Fig. 2. *Sargassum spathulophyllum* J.Tanaka, H. Murakami & S.Arai. 1. Holdfast with lobes. 2. Hook-shaped leaf. 3. Vesicle. 4. Female receptacles in racemose clusters. 5. Cluster of female receptacles. 6. Female receptacle. 7. Cluster of male receptacles. 8. Three kinds of once-branched male receptacles. 9. Male receptacle with proliferations. 10. First formed horizontal leaf. Scale bar: 1 cm (1–4), 1 mm (5–10).

with linear to lanceolate bracteal leaves, petiolate (Fig. 2-4). Female receptacles 1–6 mm long, 0.5–0.8 mm in diameter, usually slightly compressed above and ovate or occasionally subterete in older plants, apices often retuse (Figs. 2-5, 2-6). Male receptacles 4–10 mm long, 1–1.5 mm in diameter (Fig. 2-7), lanceolate or sometimes ovate when young, compressed and often subterete in older plants, simple or occasionally once branched (Fig. 2-

8), or with several proliferations when older (Fig. 2-9), smooth when young, slightly verrucose in older plants.

Phenology

This species is perennial. Young thallus begins to appear in summer to early autumn. Thallus is 5–10 cm high. Main branches are 1–2 cm in length with several ascending leaves. In mid autumn to winter, thallus is 10–20 cm high. In winter to early spring, thallus becomes 15–25 cm high and issues some short lateral branches (Fig. 2-10). In spring, it becomes 40–50 cm high. In late spring to early summer, thallus grows to their full length of 50–80 cm high. Thallus begins matured with small receptacles appeared in the end of June. In mid summer, lower leaves begins to fall off. In the end of summer, most of branches and leaves fall off and only the basal part of the thallus remains. New main branches are issued in all seasons.

Ecology

In Nabeta Bay, *Sargassum spathulophyllum* occurs on open rocky shores exposed to strong wave action. The species grows on the upper surface or edge of rocks in lower littoral zone to 2 m deep. The main growing zone is approximately 1 m deep, which is the upper limit of *Eisenia bicyclis* Setchell that forms a marine forest down to 3–4 m deep. In the upper growing zone of *S. spathulophyllum*, it sometimes grows intermingled with *Sargassum nigrifolium* Yendo and *Sargassum yamadae* Yoshida & T.Konno.

Discussion

The genus *Sargassum* is divided into two groups on the basis of the main branch morphology. They are often referred as "axes" by Setchell (1931) or "axes of primary branches" by Womersley (1987), and the leaf, which is referred as "leaves and divisions" by Setchell (1931), "laterals on primary branches" by Womersley (1987). The first group (Phyllotrichia, Schizophycus) has more or less foliar primary branches with unclear main branches, and the second group (Bactrophycus, Arthrophycus, Sargassum) has primary branches with simple leaves distinct from clear main branches (Setchell 1931, Yoshida 1984, Womersley 1987, Yoshida 1988). Furthermore, Yoshida (1983) focused on the leaf plane especially at the early stage of the leaf development, and he presented another grouping: the first group with vertical leaves (Phyllotrichia, Schizophycus, Sargassum), and the second group with horizontally expanding leaves (Bactrophycus, Arthrophycus). *Sargassum spathulophyllum* has spatulate leaves on ancipitous main branches (Fig. 1) and the horizontal leaf plane. From this point of view, it is clear that *S. spathulophyllum* belongs to the second group.

Difference between Bactrophycus and Arthrophycus is based on the receptacle morphology: the former having simple receptacles and the latter having more or less compound ones (Setchell 1931, Yoshida 1983). According to Yoshida (1983), some Japanese species of Bactrophycus sometimes have forked or dentate receptacles, and not simple ones. He stressed the need for further comparative studies on receptacle morphology between Bactrophycus and Arthrophycus. He tentatively placed all species with the horizontal leaves distributing in the northern hemisphere into Bactrophycus, and those in the southern hemisphere into Arthrophycus. Judging from the known range of distribution of *S. spathulophyllum* possibly occurring only in the northern hemisphere and its receptacles are simple or occasionally divergent without awns or spines, it is reasonable that *S. spathulophyllum* could be placed in Bactrophycus.

Sargassum spathulophyllum has the secondary attaching discs on creeping stems (Fig. 1) and non-terete receptacles (Figs. 2-6, 2-8).

Table 1. Comparison among the species of genus *Sargassum* sect. Repentia

Characters	*S. spathulophyllum*	*S. okamurae**	*S. nigrifolium**	*S. yezoense**	*S. yamadae**
thallus height (m)	0.8	0.6	0.7	1.0	1.5
basal part	weakly fused	weakly fused	weakly fused	weakly fused	fused well
section of main branches	ancipitous	flat	ancipitous	triquetrous with round edges	triquetrous with sharp edges
torsion of main branches	none	strongly twisted	none	weakly twisted	more or less twisted
phyllotaxis (lower)	1/2	1/2	1/2	1/3	1/3
shape of lower leaves	spatulate to oblanceolate	narrow lanceolate to linear	elliptical to lanceolate	long elliptical to broad linear	ovate or spatulate
leaf margins	entire	entire	entire	entire or coarsely serrate	entire
secund	none	frequent	none	none	none
retroflexy	strong	slight	none	none	strong
vertical leaves	present	absent	present	absent	absent
midribs	evanescent	evanescent	evanescent	evanescent	not conspicuous
cryptostomata	absent	rare or absent	very rare	present	rare or absent
shape of receptacles	ovate or lanceolate, comprssed	spatulate or oblanceolate	obovoid to spatulate	broad spatulate or obovoid	obovate or spatulate
maturation	summer	autumn to winter	spring to early summer	summer	late spring to summer

*Data from Yoshida and Konno (1983) and Yoshida (1983)

These characteristics are sufficient to place the species into the section Repentia under Bactrophycus (Yoshida 1983). Table 1 shows the differences of morphological characteristics between *S. spathulophyllum* and the related species in Repentia. *Sargassum spathulophyllum* is clearly distinct from the other members of Repentia: *Sargassum nigrifolium* Yendo has the dentate receptacles (Okamura 1956); *S. yamadae* Yoshida & T.Konno and *S. yezoense* Yoshida & T.Konno have leaves with a serrate or dentate margin, and triangular main branches (Yoshida and Konno 1983, Yoshida 1983); *S. okamurae* Yoshida & T.Konno has the flat main branches and the leaves frequently secund. Yoshida and Konno (1983) recognized two types of basal parts composed of a holdfast and several stems in Repentia: one is well developed basal part like *S. yamadae*, and another is weakly fused basal part like *S. okamurae*, *S. yezoense*, *S. nigrifolium* and *S. spathulophyllum.*

Sargassum spathulophyllum has creeping stem as commonly seen in Repentia, and it is clearly distinguished from *S. segii* of the section Halochloa that has an erect stem (Yoshida

1983). Although these two species belong to the different sections, they share many common features except in the stem morphology. *Sargassum spathulophyllum* has some lobes on the holdfast (Fig. 2), and its lobes are usually covered with creeping stems. No species with lobes on a holdfast was reported among Repentia. The young thallus of *S. segii* has lobes on holdfast similar to those of *S. spathulophyllum*, and its lobes become conspicuous when older (Segi 1948, fig. 2; Yoshida 1983, fig. 40).

The retroflexy of petiole is the key feature for subgrouping of Bactrophycus (Agardh 1889, Yoshida 1983). In the sections of Bactrophycus, Halochloa is the only section with the retroflexy according to Yoshida (1983). All species of Halochloa have strongly retroflexed leaves except *S. araii.* On the other hand, the section Repentia shows various degrees of the retroflexy which is sometimes the key character of the species (Yoshida and Konno 1983) as follows: no retroflexy exists in *S. yezoense* and *S. nigrifolium* (Yendo 1907, Okamura 1956, Yoshida and Konno 1983, Yoshida 1983), the weak retroflexy exists in *S. okamurae* and the strong one in *S. yamadae* (Yoshida and Konno 1983, Yoshida 1983). *Sargassum spathulophyllum* and *S. yamadae* have strong retroflexed leaves. *Sargassum spathulophyllum* most resembles *S. segii* of Halochloa in the extent of the retroflexy and to the petiole morphology.

Sargassum spathulophyllum, *S. segii* and *S. nigrifolium* have the conspicuous vertical leaves throughout the main branch except the lowermost part (Fig. 1, Yoshida 1983). In the subgenus Bactrophycus, two other species of the section Teretia, *S. hemiphyllum* (Turner) C.Agardh and *S. miyabei* Yendo have the vertically expanding leaves only on the upper main branches (Yendo 1907, Okamura 1956, Yoshida 1983).

Sargassum spathulophyllum and *S. segii* have the retroflexed petioles and the twisted leaf bases on which the leaves vertically spreading. This characteristic is clearly distinct from *S. nigrifolium* (Yoshida 1983), and is a feature exclusive to *S. spathulophyllum* and *S. segii* in Bactrophycus.

In *S. spathulophyllum* and *S. segii*, their leaf shapes are often similar to the middle to upper main branches, even though *S. segii* has more elliptical and broader leaves than *S. spathulophyllum.* On the lower main branches, they are clearly distinct from each other, with *S. spathulophyllum* having linear to spatulate leaves spreading at longer interfolial distances (Fig. 1) and *S. segii* having broader leaves at shorter distances.

Sargassum segii usually has vesicles similar to those of *S. spathulophyllum* (Segi 1948, fig. 1). Yoshida (1994) suggested the paucity of vesicles is a common feature in surf-dwelling species. *Sargassum spathulophyllum* growing on the shore with strong wave action, rarely has vesicles, while *S. segii* growing subtidally, frequently has vesicles.

Sargassum segii has been found in Mie Pref. (Yoshida 1983) not in Shizuoka Pref., whereas *S. spathulophyllum* occurs in both localities. The specimens of *S. spathulophyllum* collected in October from Mie were fertile with many lateral branches on the upper part of thallus. *Sargassum spathulophyllum* could be matured in autumn to winter in Mie Pref. as *S. segii*, and against in the mid summer in Shizuoka.

We would like to express our gratitude to Dr. J.A. West in the University of Melbourne for his critical reading the manuscript. We are very grateful to Dr. T. Yoshida in Hokkaido University for the loan of the specimens, to Dr. Y. Yokohama in the Shimoda Marine Research Center of the University of Tsukuba for his useful suggestions, and to Dr. M. Maegawa and Dr. A. Kurashima in Mie University for

their cooperation for collecting *Sargassum segii.*

References

Abbott I. A. 1995. *Sargassum* species. *In*: Abbott I. A. (ed.), Taxonomy of economic seaweeds V: 1.

Agardh J. 1889. Species Sargassorum australiae. Kgl. Sv. Vet.-Akad. Handl. **23**(3): 1–133.

Okamura K. 1956. Nippon Kaiso Shi. pp. 964. Uchida Rokakuho, Tokyo (in Japanese).

Philips N. 1995. Biogeography of *Sargassum* Phaeophyta in the Pacific basin. *In*: Abbott I. A. (ed.), Taxonomy of economic seaweeds V; 107–144.

Segi T. 1948. New species of *Sargassum* from Kii. J. Jpn. Bot. **22**: 97–99.

Setchell W. A. 1931. Hong Kong seaweeds, II. Hong Kong Naturalist **2**(4): 237–253.

Tseng C. K., Yoshida T. and Chiang Y. M. 1985. East Asiatic species of *Sargassum* subgenus *Bactrophycus* J. Agardh (Sargassaceae, Fucales), with keys to the sections and species. *In*: Abbott I. A. (ed.), Taxonomy of economic seaweeds I: 1–14.

Womersley H. B. S. 1987. The marine benthic flora of southern Australia. Part II. 484 pp. South Austr. Gov. Print. Division, Adelaide.

Yendo K. 1907. The Fucaceae of Japan. J. Coll. Sci. Tokyo Imp. Univ. **21**(12): 1–147.

Yoshida T. 1983. Japanese species of *Sargassum* subgenus *Bactrophycus* (Phaeophyta, Fucales). J. Fac. Sci. Hokkaido Univ. Ser. 5, **13**(2): 99–246.

——— 1984. Taxonomical and distributional accounts of *Sargassum.* Kaiyo to Seibutu (Aquabiology) **6**: 432–438 (in Japanese).

——— 1988. Western Pacific Asiatic species of *Sargassum* subgenus *Sargassum* with keys to the species. Introduction. *In*: Abbott I. A. (ed.), Taxonomy of economic seaweeds II: 1–3.

——— 1989. Systematics of *Sargassum* (Fucales, Phaeophyceae). *In*: Kumar H. D. (ed.) Phycotalk **1**: 229–238.

——— 1994. Three new species of *Sargassum* (Sargassaceae, Phaeophyta) from Japan. Jpn. J. Phycol. **42**: 43–51.

——— 1998. Marine Algae of Japan. 1222 pp. Uchida-rokakuho, Tokyo (in Japanese).

——— and Konno T. 1983. Taxonomic study on *Sargassum sagamianum* Yendo and related species (Phaeophyta, Fucales). Bot. Mag. Tokyo **96**: 145–157.

———, Yoshinaga K. and Nakajima Y. 1995. Check list of marine algae of Japan (revised in 1995). Jpn. J. Phycol. **43**: 115–171.

村上裕重[a]，新井章吾[b]，田中次郎[c]：日本産褐藻の新種ヘラナラサモ（ヒバマタ目）の形態

静岡県伊豆半島下田市において褐藻綱，ヒバマタ目，ホンダワラ科，ホンダワラ属，バクトロフィクス亜属の新種 *Sargassum spathulophyllum* J. Tanaka, H.Murakami & S.Arai（和名ヘラナラサモ）を採集し，その記載を行った．本種の特徴は次の五つである，1)主枝下部の葉はヘラ状全縁で基部は反曲する，2)主枝中部の葉は垂直に拡がる，3)主枝（main branch）は二稜形で，その稜は平滑である，4)茎（stem）は匍匐し，二次的な付着器（secondary attaching disc）を生じる，5)生殖器床（receptacle）は分枝せず，円柱状でない．1)の特徴により種形容名および和名がつけられている．

本種はハロクロア節のナガシマモクと葉や主枝などの形態において類似するが，4)の特徴から両種の区別は可能であり，レペンティア節に所属させることが適当である．同節の他種であるヒラネジモク（*S. okamurae*），ナラサモ（*S. nigrifolium*），エゾノネジモク（*S. yezoense*），アズマネジモク（*S. yamadae*）との形態上の比較から新種であることが明らかとなった．

（[a]臨海生物研究所，[b]海藻研究所，
[c]東京水産大学）